NATIONAL BUREAU OF STANDARDS REPORT

8537

Development, Testing, and Evaluation of Visual Landing Aids
Consolidated Progress Report for the Period April 1 to June 30, 1964

By
Photometry and Colorimetry Section
Metrology Division

NBS

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT

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NBS REPORT

8537

Development, Testing, and Evaluation of
Visual Landing Aids

Consolidated Progress Report
to
Ship Aeronautics Division
and
Meteorological Management Division
Bureau of Naval Weapons
Department of the Navy

and to
Federal Aviation Agency
Washington, D. C.

For the Period
April 1 to June 30, 1964

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Development, Testing, and Evaluation of Visual Landing Aids
April 1 to June 30, 1964

I. REPORTS ISSUED

Report No.	Title
8343	Development, Testing, and Evaluation of Visual Landing Aids, Consolidated Progress Report for the Period January 1 to March 31, 1964
8358	The Effective Intensity of Flashing 399PAR Lamps
21P-102/63 Supp.	Life Tests of Seven Developmental 6000-Hour Lamps For Use in a 300-mm Code, or Hazard, Beacon
21P-30/64	Intensity Distribution Measurements of a PAR-56 Flashtube in Two Semiflush-Mount Type Airport-Marker Lights
21P-35/64	Watertightness and Static-Load Tests of Three Runway Inset-Light Bases Manufactured by Vega Industries, Inc.
21P-36/64	Intensity Distribution Measurements of Ten Type Q20A/PAR56 and Ten Type Q20A/PAR56/2 Developmental Approach- and Runway-Light Lamps Manufactured by General Electric Company
21P-38/64	Tests of 90-Volt, 100-Watt Airport-Marker Lamps Manufactured by General Electric Company
Memorandum Report	Summary of Meteorological Observations at Arcata Airport 1962-1963
Memorandum Report	"Slant" Visibility Measurements

II. VISIBILITY METERS AND THEIR APPLICATION

Slant Visibility Meter Field Tests.

Correlation of Backscatter Measurements with Transmittance Measurements. A study is being made of the correlation between measurements of backscatter of light and of transmittance of light in various atmospheric conditions by correlating the readings of the slant visibility meter (SVM) when the projector beam and line of sight of the detector are horizontal with transmittance measurements made with transmissometers near the slant visibility meter. The transmittance was measured by a 500-foot baseline transmissometer parallel to the line of sight of the SVM detector (when it is in the horizontal position) and by a 60-foot baseline transmissometer across the area where the field of view of the SVM detector intercepts the SVM projector beam when the beam is horizontal. See figure 1. The backscatter measurements were obtained from the SVM records when the SVM projector beam was horizontal and were corrected for changes in sensitivity, gain setting, and projector intensity. Data for the period of October through December 1962 were used. This period was selected because the SVM equipment was performing very satisfactorily; the calibrations of the equipment had been carefully checked; and there were frequent and extended periods of low visibility conditions. These data were obtained for atmospheric conditions with transmittances over a 500-foot baseline ranging from 0.995 to 0.000020. The data were taken periodically during all times when the SVM beam was horizontal, -- at three-minute intervals during test and when the SVM was scanning and at five-minute to hourly intervals during periods when the drive was stopped with the projector beam in the horizontal position. There were approximately 1425 sets of data in these tabulations.

The results of these tabulations are summarized in figures 2 and 3. (Plots of data tabulated for the 1961 fog season and for 1958 when the slant visibility meter was located at another site on the airport show very similar characteristics.) The curve of the average of these data differs from a simple theoretical curve in two respects. First, the maximum occurs when transmittance over a 500-foot baseline is between 0.3 and 0.5 instead of at a transmittance of 0.58. Second, the SVM reading tends to remain constant for transmittances below 0.001 instead of continuing to decrease with decreasing transmittance. It is believed that the latter effect results from second- and higher-order scattering. There is a significant lack of correlation between the SVM reading and transmittance for atmospheric conditions at different times but with similar transmittances. For a given interval of transmittance, the SVM output varied widely. One reason for the amount of variation in SVM output is the horizontal nonuniformity of the fog. If the fog is less dense in the zone where the SVM detector views the SVM projector beam, the scattering of the light and resulting SVM

output will be low. The reverse is true when a dense patch of fog is in this zone. Another reason for the variation in SVM output is the variation in the particle size distribution of fogs which have similar transmittances.

Analysis of Basic Fog Layer. The vertical structure of the fogs at Arcata may be considered as being composed of a series of horizontal layers such that in each layer the rate of change of the extinction coefficient with height is constant. The bottom layer of fog may be only a few feet or may be several hundred feet thick, but, as was reported in previous progress reports, the fogs at Arcata can be considered as a single layer at least 200 feet thick for a great majority of conditions without serious error. This basic layer is seldom uniform in density but tends to either increase or decrease in density with height. The attenuation of light as a function of height within a fog layer can be represented by the equation

$$\sigma = \sigma_o \ (1 + ah)$$

where σ is the attenuation at any height, σ_o is the attenuation at ground level or when the SVM projector beam is horizontal, h is the height above the horizontal, and a is a constant. The frequency distribution for the values of a_{200} of the basic layer for 195 scans is shown in figure 4. Note that for most scans the changes with height are small but for larger changes the density is more likely to increase than to decrease.

Analysis of Slant Visibility Measurement Techniques. A brief memorandum report has been prepared describing and analyzing the several methods of slant visibility measurements which have been proposed. Measurements along the glide path are not feasible in dense fog because of the very low transmittances involved. Other methods are limited in usefulness by time and space variations in fog density.

Shipboard Visibility Meter. Tests have been made of several circuit combinations to improve the signal-to-noise ratio in clear daylight conditions and to simplify the design of the electronic components. A quasi peak-reading system was found to provide a very satisfactory signal-to-noise ratio and at the same time a relatively simple circuitry. The a-c component of the output of the photomultiplier tube is amplified by an amplifier with a gain of about 100. The output of this amplifier is fed through a diode to a switching circuit that separates the signal produced by the backscattered light pulse from the standard light pulse. These signals charge the test and standard capacitors to voltages equal to the peak voltage of the test and standard signals respectively. The capacitors discharge through high impedance circuits and the average discharge currents are measured by

electrometers whose output is proportional to the logarithms of the discharge currents. The difference between the two electrometer outputs is measured and recorded. This difference is independent of the output of the flashtube, the sensitivity of the photomultiplier and the gain of the amplifier and hence changes only with changes in the amount of backscattered light. As long as the peak of the pulse signal is greater than the peaks of the background noise, the readings are unaffected by the noise.

The instrument can handle a thirty-fold change in signal strength whereas a thousand-fold range is required to cover visibilities ranging from 1/4 to 10 miles. Hence changes in amplifier gain, photomultiplier voltage, or light output will be required as the visibility changes widely. The required changes in instrument parameters may be made manually, or automatically if required. The instrument is now being tested and visibility recordings are being made.

Transmissometer

High pulse rate receiver. Studies are being made of circuit changes in the photopulse unit of the transmissometer which will increase the pulse rate. A modification which will increase the clear weather pulse rate by a factor of 5 has been developed and is now being tested.

Airborne Turbidity Meter. Work has been carried out to improve the operation of the turbidity meter developed by Cook Research Laboratories. Various modifications, mechanical and electrical, have been made which significantly improve the sensitivity of the instrument. There is still some doubt that the unit can be made sufficiently sensitive to detect visibilities of a few miles. It appears that rather complete redesign of the unit would be required.

The first step taken was to increase the light output and also prevent the direct transmission of the light from the lamps through internal reflections in the glass to the photocell. This was accomplished by making a new top for the unit with separate windows for the photocell and each pair of lamps. The cell was covered with the Corning U.V. filter, but the lamps were covered with clear glass which did not seem to significantly attenuate the light. A metal baffle was placed between the lamps and the cell to provide both light shielding and electrical shielding. After these modifications, the output signal with the photocell covered with an opaque material was 0.5 ma due to amplifier noise. The device under these conditions was sensitive only to a dense cloud of smoke directly in front of the instrument.

Since the sensitivity seemed to be primarily limited by internal noise, changing the output circuit to a synchronous detector was the

next step. This also required removing the compression circuit since nonlinearity before the synchronous detector destroys the detector's effectiveness. The gain of the a-c amplifier was thereby increased. With larger signals now available from the amplifier, the output emitter follower had to be modified to deliver a larger undistorted output to the synchronous detector. After these changes, the device would detect a much smaller amount of smoke and an attempt was made to record turbidity out-of-doors.

It was immediately evident that the unit was primarily sensitive to bright visible light. Investigation showed that the selenium photocell generated a large amount of noise when subjected to daylight, even with the U.V. filter in front of it. Enough of this noise was in the pass band of the 200 Hz. filter to nearly saturate the output amplifier stage. The device was practically useless during daylight hours, so an effort was made to eliminate this photocell noise problem.

Several smaller International Rectifier selenium photocells, type B2PL, were tried in series and parallel. These also seemed to generate about the same amount of noise when exposed to light. Two or three of these cells in series produced no more signal output than one, but several in parallel would provide more signal output. Four in parallel still did not give as much output as the original B-15 cell but this would be expected since the cells are current generators whose output is proportional to area for low light levels and the four B2PL cells have a combined area of about half that of the B-15. The original B-15 cell was the most satisfactory of those tested. It was now apparent that some other means of reducing the noise would have to be found. An input transformer reduces the noise introduced into the system to an acceptable level. The d-c resistance across the cell has been lowered from about 2k ohms to less than 100 ohms, while the a-c impedance is stepped up to a suitable value to drive the preamplifier. The noise level does not noticeably increase except when direct sunlight falls on the cell.

No attempt has been made to incorporate the synchronous detector circuitry, or the input transformer, into the original package. At present they are attached to the sides of the case. The input transformer being used is relatively large since excellent shielding is required to prevent hum pickup. A high impedance d-c vacuum tube voltmeter is required to drive the chart recorder without loading the long time constant filter on the output of the synchronous detector. The unit will now detect a rather fine stream of smoke as opposed to the dense cloud originally required; but its sensitivity to haze, fog, or clouds remains to be determined. It appears that the visibility would have to be very poor before fog would be detected.

The main factor limiting the sensitivity now seems to be the small amount of light given off by the four AR-4 lamps. Increasing the number of lamps might help, but changing to another type of lamp of greater intensity would probably be required for any significant improvement. With the light now available, the device is primarily sensitive to reflecting matter within a few feet of the unit. A sharper a-c pass band filter would further reduce the noise components not at the modulation frequency and prevent them from saturating the final amplifier stages. Further reducing the visible and infrared light that reaches the cell would help to lower the noise level in sunlight. Now that the input noise has been reduced with the use of an input transformer, a better low-noise pre-amplifier might be of some help. If sufficient sensitivity is obtained, some type of logarithmic scale compression would have to be employed in the d-c output circuit to allow operation over the wide range of atmospheric conditions which might be encountered. For reasons previously mentioned, this cannot be incorporated in the a-c amplifier. Future steps would require repackaging the unit to include brighter lamps and the other possible modifications.

Meteorological Summary. The meteorological summary of visibility and ceiling observations by the Federal Aviation Agency at the Arcata Airport for 1962-1963, reported last quarter, has been issued as a memorandum report to make the data more readily accessible.

III. AIRFIELD LIGHTING AND MARKING

Navy Taxiway Lighting Standard. The draft of this Standard has been completed except for the figures, and sent to NBS at Washington for review and discussion with personnel of the Bureau of Naval Weapons. The figures will be prepared after this review in order to include suggested changes and revisions.

Effective Intensity of Flashing 399PAR Lamps. NBS Report 8358 entitled The Effect Intensity of Flashing 399PAR Lamps was issued. It presents the results of a study of the intensity vs. time, and of the effective intensity of flashing 399PAR lamps, the type used as the wave-off lights in the optical landing system. The study includes the characteristics of the white light, as well as of the beam transmitted through aviation-red and aviation-green filters, at the voltages applied to the datum lights on the seven steps of the optical landing system: 21, 27, 35, 44, 60, 80, and 115 volts.

The method of computing the effective intensity, as presented in the report, may be used for any flash rate for these lamps at any voltage for which the instantaneous intensity-time curve is known. The method may be used for other lamps with approximately the same current rating, with sufficient accuracy for engineering estimates.

Study of the Effective Intensity of PAR-Type Lamps Mounted in Rotating Beacons. All work has been finished and a report has been drafted.

PAR-56 Flashtube in Two Semiflush-Mount-Type Airport Marker Lights. Tests were made of the intensity distribution of an assembly of the following components:

(1) A FT34/HT flashtube

(2) A type CD-2 condenser-type power supply furnishing a nominal 60-watt-second pulse

(3a) A bidirectional, one-half-inch projection prismatic-type BB45 airport-marker light

(3b) A bidirectional, one-inch projection prismatic-type B1 airport-marker light.

One-Half-Inch Projection Light. The vertical beam spread at 50% of peak intensity is 18°. The elevation of the beam axis is 10°. The highest intensity recorded was 1000 candelas.

One-Inch Projection Light. Since the light has a 3.5° toe-in, 0.0° horizontal is 3.5° from the vertical plane perpendicular to the prism exit face. At 3.5° the vertical beam spread is 24°. The elevation of the beam axis is 11°. The highest intensity recorded for this unit was 1850 candelas, on a horizontal traverse at 6° elevation. NBS Test Report 21P-30/64 was issued giving the results of the tests.

Q6.6PAR64/3 Iodine-Cycle Lamps for the VASI System. Photometric testing was begun on a group of Q6.6A/PAR64/3 iodine-cycle lamps for use in the VASI system. A preliminary investigation of the beam pattern, especially in the vertical planes perpendicular to the filament axis, showed much larger center "dips" in intensity than were associated with the conventional lamps previously tested. These "dips" are evident when the lamps tested are aimed through a slot positioned to simulate a VASI. The shadows of the quartz tubes both broaden and deepen these "dips." The effect of the beam pattern on the output of a VASI unit will be studied.

Developmental Lamps for Use in a C-1 (L-819) Runway-Edge Light. Eight developmental 200-watt, 6.6-ampere, T-14 lamps manufactured by the General Electric Company have been tested. The lamps are designed for a 300-hour life and a lumen output of 4500 to 4600 lumens. Luminous output measurements and life tests have been made. Intensity distribution measurements were made of two of the lamps. A report is being drafted.

700-Watt, C-5 Filament, 6000-Hour Lamps for Code Beacons. Life tests of four 700-watt, 6000-hour code beacon lamps with C-5 filaments were concluded. The times to burnout of lamps 2, 3, and 5 were 3002, 3979, and 4200 hours, respectively. Lamp #4 showed a luminous output maintenance of 74% (8040 lumens) at 70% of rated life, 4200 hours. NBS Test Report 21P-102/63, Supplementary, was issued. (Lamp #4 burned out at 5200 hours; this information was not included in the report.)

Operating Characteristics of 90-Volt, 100-Watt Lamps Supplied Through Series Transformers. The report on this task has been completed and issued as NBS Test Report 21P-38/64. These lamps are suitable for use as loads for 200-watt transformers with 6.6-ampere secondaries when saturation-type operation is required. There were appreciable differences in lamp performance, depending on the type of constant-current regulator energizing the circuit. However, these lamps should be suitable for use with the types of regulators now being used in runway lighting circuits.

Intensity Maintenance of 500-Watt, PAR56 Quartzline Lamps. The photometric measurements of these lamps have been completed. A report presenting the results of the measurements is being prepared.

Lamps for "Wheels-Up Warning" Systems. A new type 500-watt, 120-volt, general service iodine-cycle lamp mounted in a PAR-56 envelope (type Q500PAR56/NSP) was tested for use in wheels-up warning systems. Lamps were flashed with a 50% On-Off duty cycle at 90 flashes per minute. Lamps were burned until failure at voltages of 180, 170, 165, and 155 v.a.c. Lamp life was very short, only 9 hours, 30 minutes at 155 volts. It was estimated that, for a lamp life of 100 hours, a voltage

of 140 volts would be required. The estimated mean effective intensity in a 5° cone at that voltage is 35 kilocandelas, which is considered insufficient to warrant usage of the lamp in wheels-up warning systems. Use of Type 300PAR56/NSP lamps, rated at 300 watts, 102-volts, was also investigated. At 185 v.a.c., lamp life was 40 hours. At this voltage, the mean effective intensity in a 5° cone is estimated to be not less than 65 kilocandelas. As the effective intensity of these lamps is only about 70% of the effective intensity of the conventional 500-watt PAR-64 general service lamps, a detailed photometric study was not made.

Temperature Measurements of a Lamp in an L-843 Inset Light. Measurements were made of the operating temperatures at the end seals of a 200-watt, 6.6-ampere, iodine-cycle lamp in an L-843 inset light manufactured by the Westinghouse Electric Corporation. Two special lamps having thermocouples attached to the end seals were supplied by the General Electric Company. The lamps were operated at rated current, 6.6 amperes, during the tests. At an ambient temperature of 80°F, equilibrium temperatures of the end seal nearest the center of the light averaged 360°C for the two lamps. This temperature exceeds the maximum temperature of 350°C recommended by the General Electric Company. A letter report is being prepared.

Radioactivated Taxiway Lights. At the request of personnel of the Shore Establishment Division, Bureau of Naval Weapons, a study was made to determine the suitability of radioactivated light sources for use as taxiway lights. Three different types of these lights were received from the United States Radium Corporation:

- Lab 737-1 Commercial Exit Sign
- Lab 724-1 One-Way Lamp (somewhat similar in appearance to a spotlight)
- Lab S-71B 360° Light Source (somewhat similar in appearance to an M-1 taxiway light)

Each unit was tested by the NBS Health Physics Section for conformance with A.E.C. regulations. It was concluded that there was negligible leaking of the krypton-85 gas from any of the signs. The gamma radiation from the contained radioactive gas presented exposures of roughly 10 mr/hr at 1 foot and 2.5 mr/hr at 1 meter. This constitutes a "radiation area," and, according to A.E.C. regulations, the units must be conspicuously posted with warning signs. The lamps were then installed on the NBS outdoor photometric range, and an M-1 taxiway light was mounted alongside them. Observations were made at night from a distance of approximately 900 feet. A faint glow was observed from the one-way lamp. The other two lights were not visible. The current from the M-1 light was then slowly increased from zero. At 3.2 amperes the intensity of the M-1 light was approximately equal to that of the

one-way lamp. At 3.4 amperes, the M-1 light was more intense than the one-way lamp.

In view of the fact that taxiway lights are not normally operated at currents as low as 3.4 amperes, it is doubtful that the use of these lamps as replacements for incandescent taxiway lights would be feasible, in spite of their long life and the fact that they require no external source of power.

Watertightness and Static-Load Tests of Runway Inset-Light Bases. Three preproduction samples of a runway inset-light base and one sample of a metal cover plate manufactured by Vega Industries, Inc. under Specification FAA-ER-430-009 were tested. Watertightness tests were made at an internal air pressure of 6 pounds/in^2 on two bases, each coupled, in turn, with the cover plate. With all bolts tightened to 150 inch-pounds, no leaks were observed. For the static-load test, a maximum load of 100,000 pounds was applied concentrically to a base and the cover plate. Maximum plastic deformation of the cover plate was approximately 1/4 inch, and of the base was approximately 1/10 inch. NBS Test Report 21P-35/64 has been issued.

Airfield Lighting Cable Connector Field Tests. The above-ground sections of the test cables were cut off and new pieces extending from the ground surface to the instrument shelter were spliced on. The above-ground sections of the original cables, particularly those on which 2400 volts has been applied for extended periods, were weather-cracking and leaking, although the buried sections of the cables appear to be in satisfactory condition. Guard rings were installed just above the ground surface so that only leakage current of the buried cable and test connectors would be measured. Four samples showed lower leakage current, nine higher, and five slightly higher than the worst leakage current condition previously recorded for the cable tested.

TSM-11 Cable Test Set. The Airport Electrician at Arcata used this equipment on two occasions during this quarter to locate grounded power cables. A fault developed in the FAA approach lighting system and assistance was given in locating the fault using the TSM-11 Test Set. The fault was accurately located. It was caused by gophers eating the insulation away. Faults in another cable with an insulation resistance of approximately two megohms to ground could not be satisfactorily located with the Set.

IV. SEADROME LIGHTING

No work was conducted in this field during the quarter.

V. CARRIER LANDING AIDS

Experimental Deck Guide Light. Four new lamps for use in the experimental deck guide light (utilizing a fiber optic assembly) have been forwarded by Sylvania Electric Products, Inc. A conference has been held with personnel of the Bureau of Naval Weapons and Sylvania Electric Products Inc. It was decided at this conference that further testing on this light, including testing of usage of the new lamps, would be suspended pending further instructions.

VI. MISCELLANEOUS TECHNICAL AND CONSULTIVE SERVICES

Review of Specifications. The following specifications and associated MS drawings have been reviewed and comments have been forwarded.

MIL-P-8944	Panel, Control, Airport Lighting, General Specification for
MIL-M-8947	Monitor Panel, Airport Lighting
MIL-F-8953	Filters, Colored, Airport Marker Light, General Specification for
MIL-B-8954	Base, Gasket and Base Plate Assembly, Airport Marker Light
MIL-L-25971	Light, Traffic, Aircraft, SDU-4/U
MIL-L-26202	Light, Marker, Airport, Semiflush, General Specification for
MIL-T-27535	Transformer, Isolation, Series Circuit
MIL-L- ----	Floodlight, Night Vision (Land Based Installation Only)
Draft	Dimmer Control Panel, Solid State, for Shipboard Application
Draft	Dimmer Control Panel, Solid State, for Land Based Application

Brightness Control of Monitor Lights. Draft specification MIL-M-8947, Monitor, Panel, Airport Lighting, specifies manual control of the brightness of the monitor lights. Observations of the operation of airfield lighting systems indicate that unneeded lighting systems are left on more frequently during the day than at night. This is attributed in part to the operator's leaving the indicator lights on the nighttime brightness setting during daylight. (There is a potential hazard in this procedure as monitor lights indicating circuit failure may not be noticed by the operator.) There are now available inexpensive solid state devices which could adjust the brightness of the monitor lights for the ambient lighting conditions in the tower. Prototypes of such devices are now being developed for use in aircraft cockpits to adjust the brightness of the instrument lighting and of the warning lights. Consideration should be given to the use of such devices to control the brightness of the monitor lights.

Lighting Committee Meeting. The IES Aviation Lighting Committee meeting at San Franciso was attended by three members of the Arcata Laboratory.

Miscellaneous Consultive Services. The frequency, duration and intensity of fog occurring at Arcata has been discussed with personnel from the California State Division of Highways. Their interests are on how fog may affect traffic on highways along coastal routes.

VII. MISCELLANEOUS

Life Testing of Series Lamps. At NBS the seasoning and life testing of aviation service lamps is performed in the Life-Test Laboratory, which occupies a separate building. There have been occasions when the testing of lamps has been delayed because the generator supplying regulated voltage is running at full capacity. In order to overcome this difficulty, a circuit was designed in such a manner that the power necessary for testing these lamps could be supplied from the laboratories in the East Building. A control cabinet was constructed and installed which permits the switching and cycling of the lamps (which are mounted in the Life Test Laboratory) from a remote station in the East Building. The output of a constant-voltage regulator is stepped up, routed through the switching and cycling control cabinet, through a 4-kva constant-current regulator, back to the control cabinet for monitoring, and then underground through existing trunks to the racks in the Life Test Laboratory.

A series of several tests utilizing this setup will be initiated immediately.

Fog Simulator Screens. In night flight tests at NAFEC using fog-simulator screens of recent production, the pilots observed the approach and runway lights at distances of several miles although the screens were designed to have visual ranges of 700 or 1200 feet. At the request of the Research Division, SRDS, FAA, a visit was made to NAFEC in an effort to resolve the difficulty. When single lights were viewed, the screens did not completely extinguish lights providing illuminances typical of approach and runway lights. The screens were then brought to Washington for densitometric study and comparison with screens of earlier production. A simple portable viewing device was constructed and the new screens were visually compared with an old screen. Although the maximum density of the new screens was less than the density of the old screen, the densities were of the same order. It was, therefore, concluded that unless the aircraft is on the runway or over the approach lights, where a high screen brightness is produced by the many lights of the system, the screens would not extinguish the approach and runway lights. Thus an auxiliary cutoff is required to limit the visual range to the design value. The viewing device has been delivered to NAFEC.

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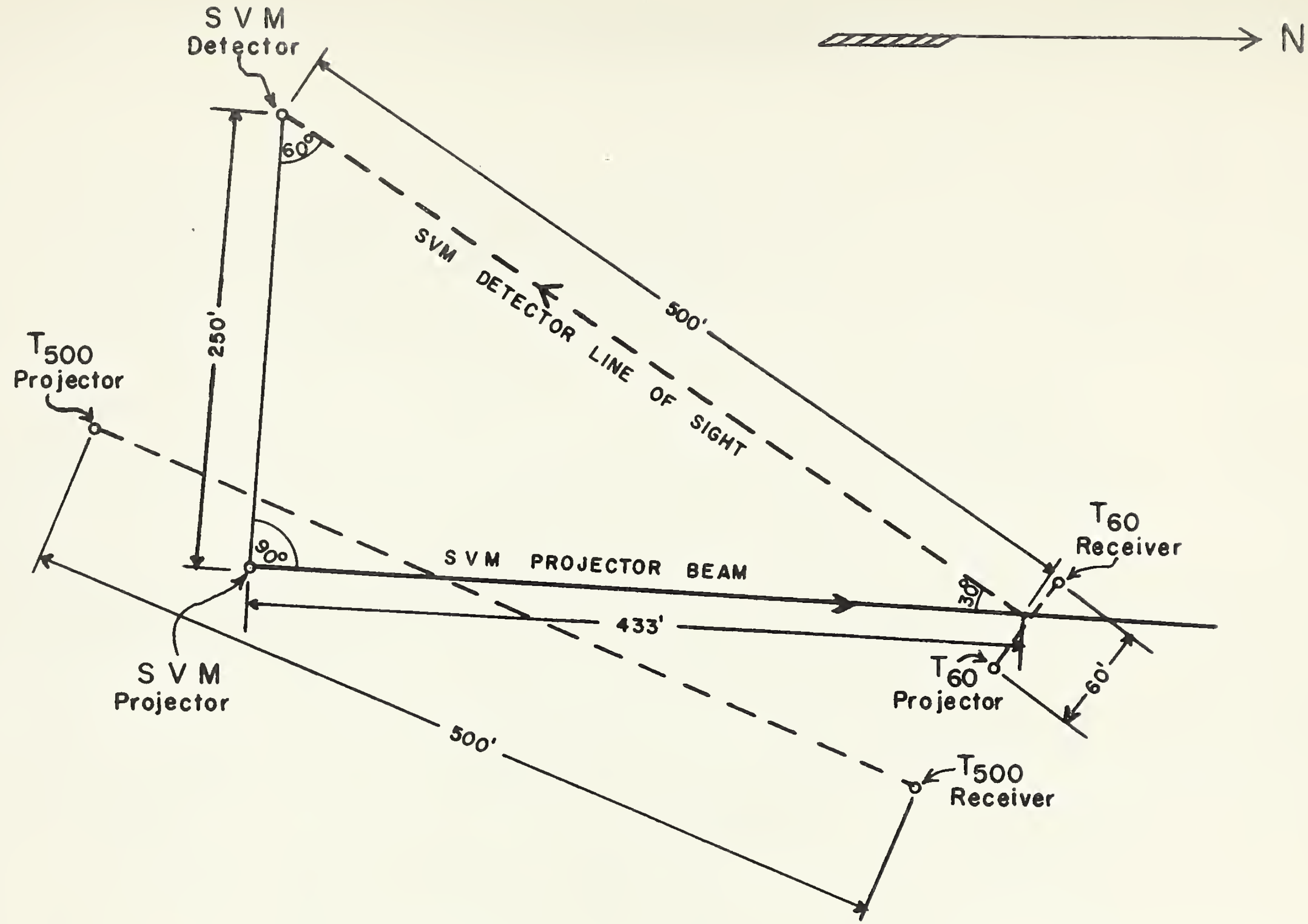

Figure 1. Location of slant visibility meter (SVM) test equipment with projector beam horizontal.

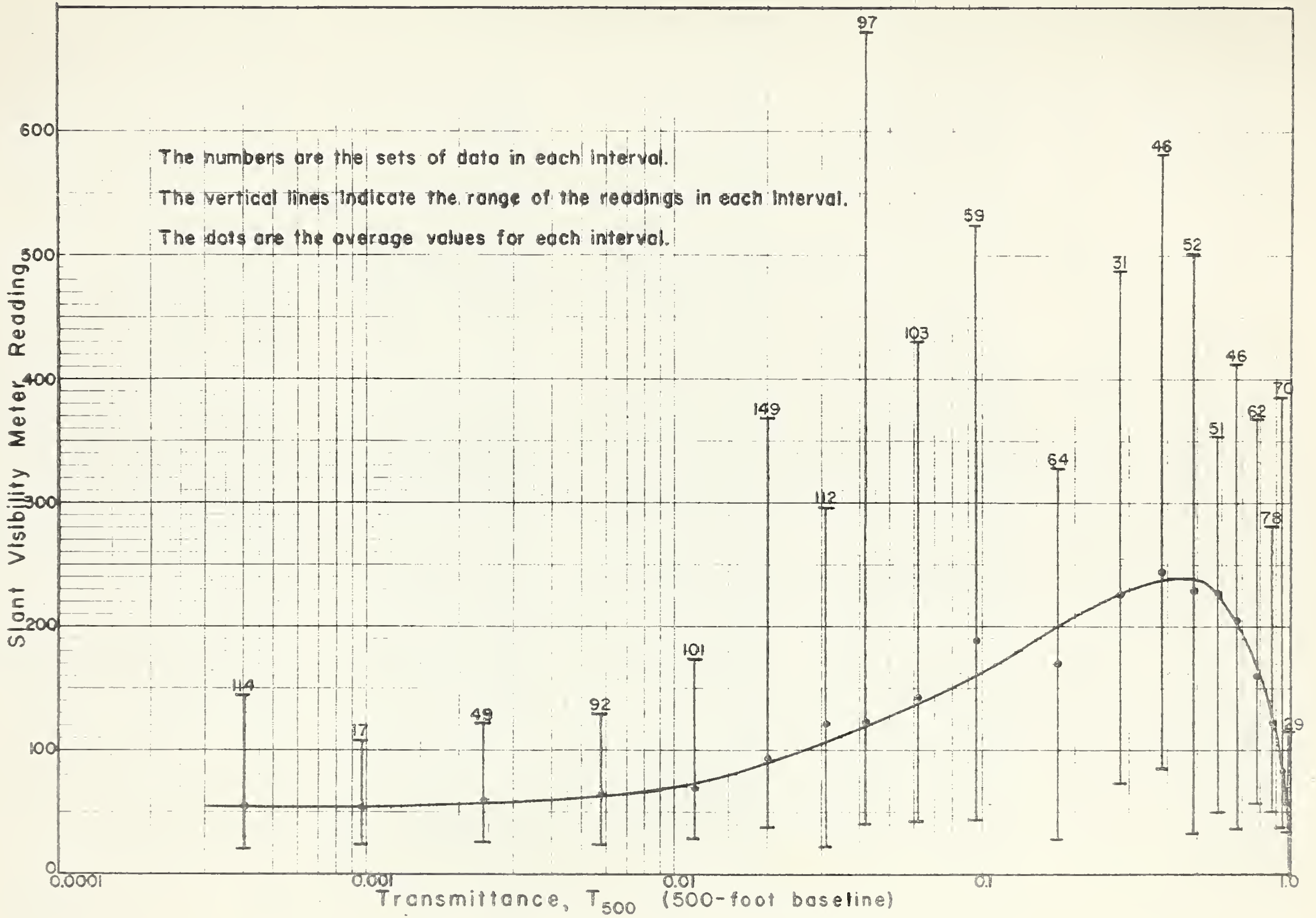

Figure 2. Correlation of slant visibility meter readings with transmittance measurements. Transmittance measured by the 500-foot transmissometer of figure 1 and reported as transmittance per 500 feet.

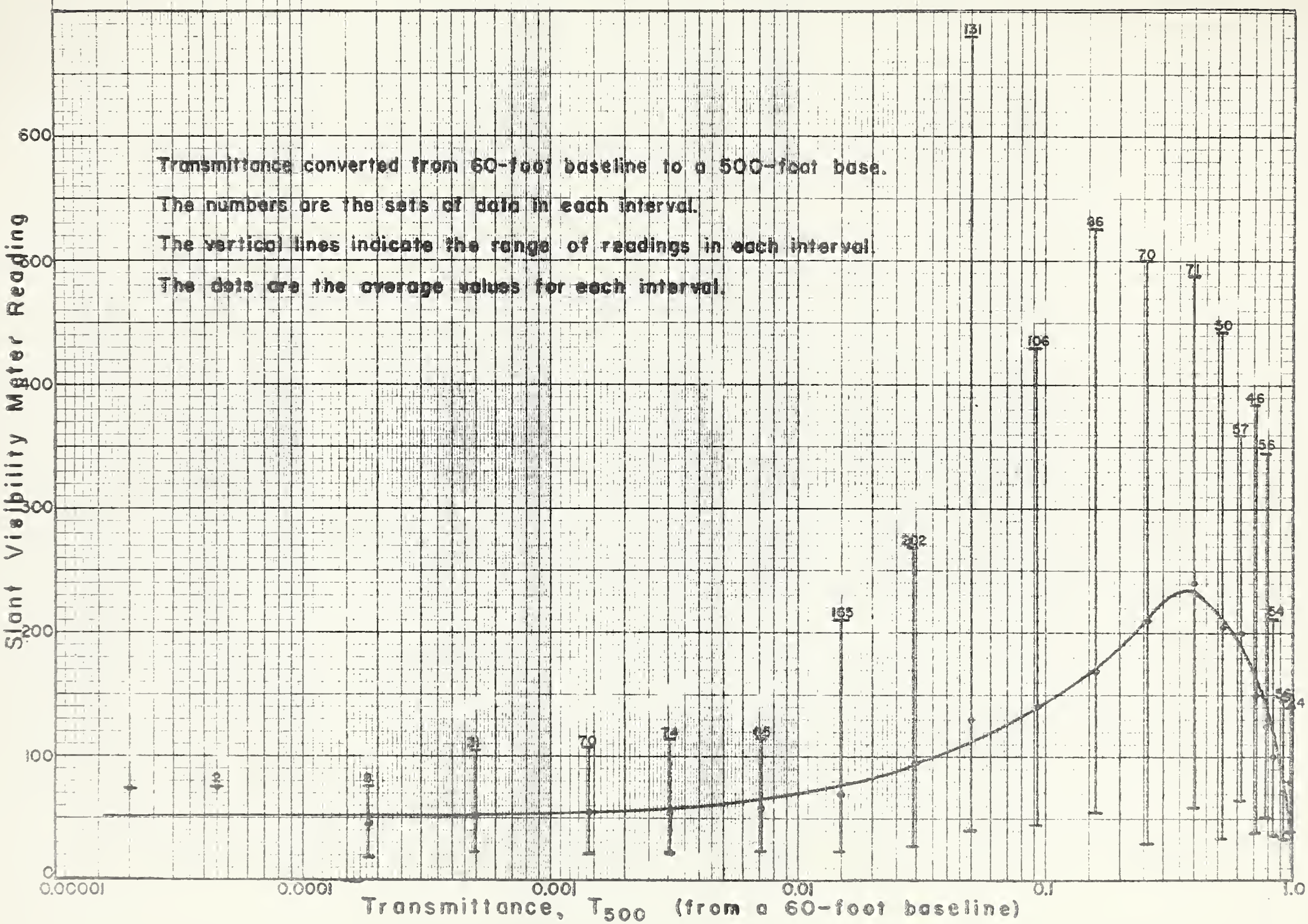

Figure 3. Correlation of slant visibility meter readings with transmittance measurements. Transmittance measured by the 60-foot transmissometer of figure 1 and reported as transmittance per 500 feet.

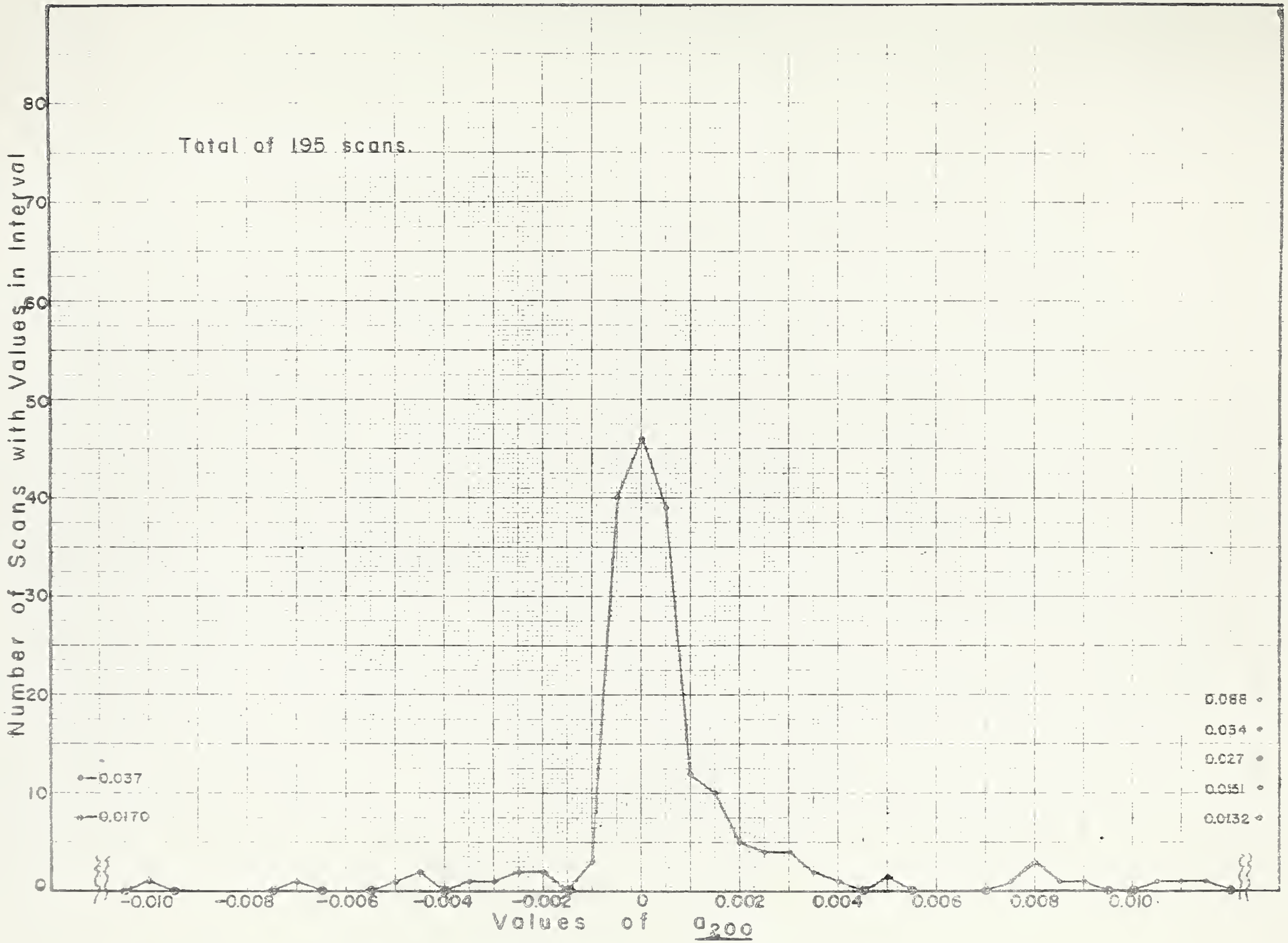

Figure 4. Change in fog density with height. Distribution of values of a_{200} assuming $\sigma_h = \sigma_o(1 + a_{200}h)$ for $0 < h < 200$. σ_h is the extinction coefficient at the height h (h in feet), and σ_o is the extinction coefficient at ground level. σ_o is determined from transmissometer measurements. a_{200} is determined from slant visibility meter readings.

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